Troubleshooting Cardiac Rhythm Devices

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There are known knowns; there are things we know we know.
We also know there are known unknowns; that is to say we know there are some things we do not know.
But there are also unknown unknowns – there are things we do not know we don't know

A few pearls

It is potentially very difficult

There are idiosyncratic aspects of all device companies

Finding out what these idiosyncrasies are, is tricky

What happened or did not happen at implant is sometimes the source event

Get as much information as you can – is your source reliable?

If it looks like a duck, walks like a duck and quacks like a duck then we probably have to consider he possibility of us having a small aquatic bird on our hands….unless it's a dragon doing an impersonation of a duck

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What do we need to troubleshoot?

LOC

Oversensing – I am seeing too much!

Undersensing – I can't see!

Inappropriate therapy – I am delivering therapy when not required or a better alternative is available:

- shocks for VT - bad
- shocks for SVT – really, really bad
- RV pacing

Lack of appropriate therapy

- Lack of ICD therapy – slow VT
- Loss of CRT - LOC, bad programming…

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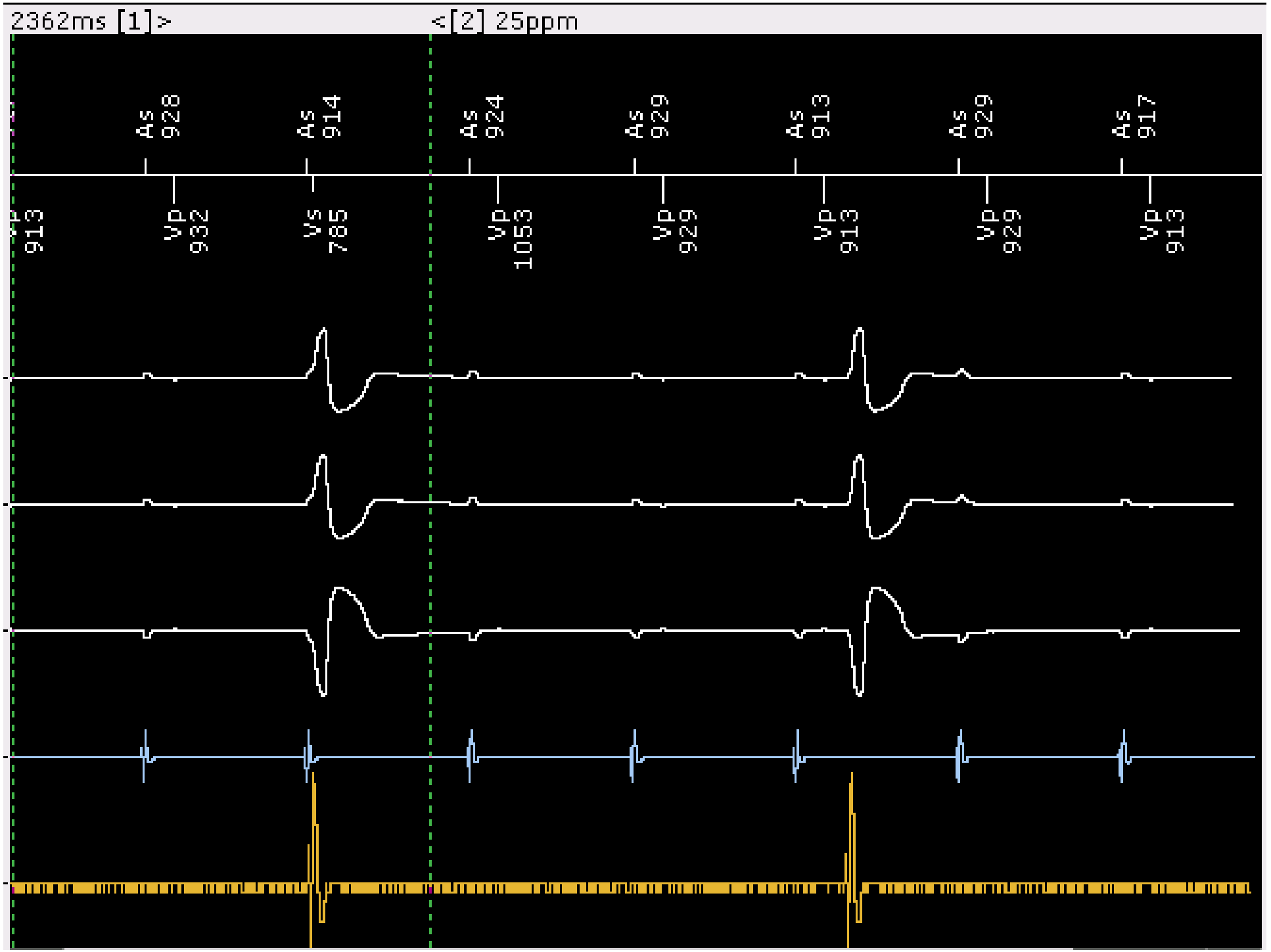
2362ms [1]>
<[2] 25ppm
As 628
As 614
As 624
As 629
As 613
As 629
As 617
Vp 913
Vp 632
Vs 785
Vp 1053
Vp 629
Vp 913
Vp 629
Vp 913

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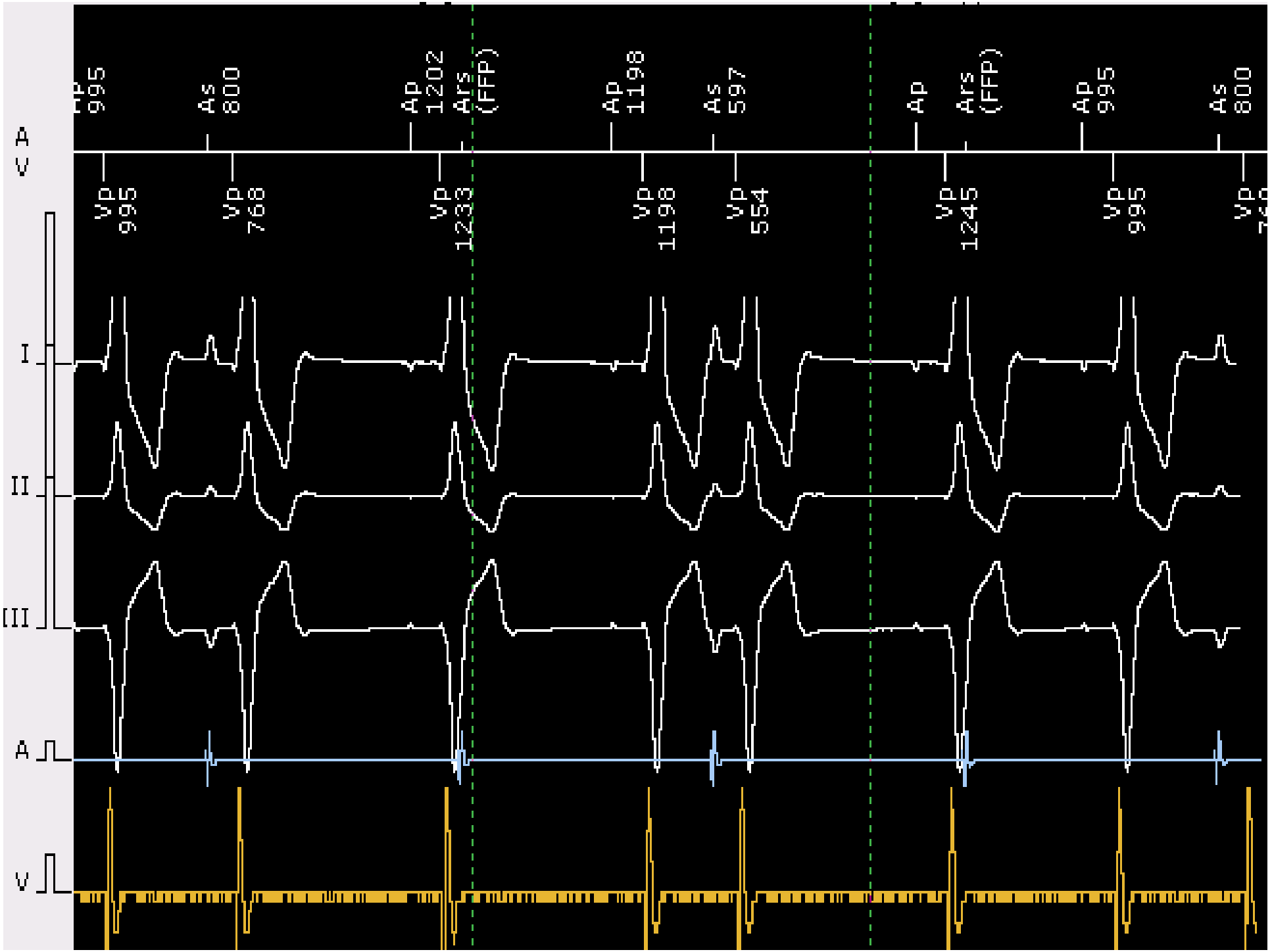
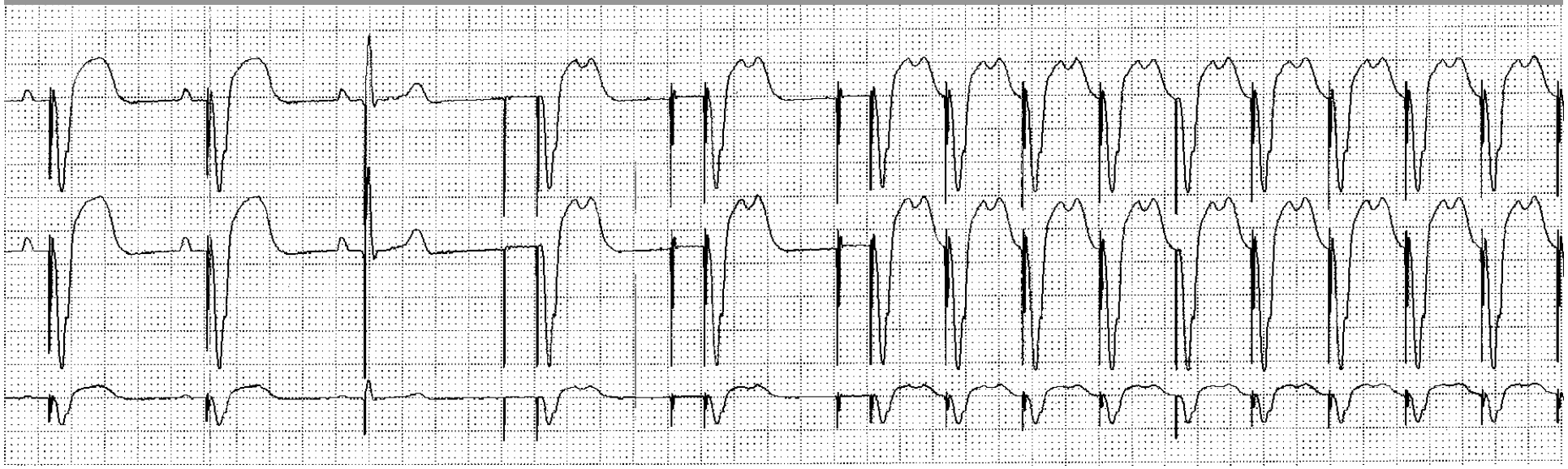

Dp 995
As 800
Ap 1202
Ars (FFP)
Ap 1198
As 597
Ap
Ars (FFP)
Ap 995
As 800
A
V
Vp 995
Vp 768
Vp 1233
Vp 1198
Vp 554
Vp 1245
Vp 995
I
II
III
A
V



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Loss of Capture

Not enough current getting to the lead tip

- lead is bust
- lead isn't plugged in correctly

Current gets to the tip but the tip but does not capture

- Drug therapy
- Infarcts

Current gets to the tip but the tip isn't where it should be

- lead has moved
- lead is perforated

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Loss of Capture

Not enough current getting to the lead tip

- lead is bust – impedance changes
- lead isn't plugged in correctly – impedance changes

Current gets to the tip but the tip but does not capture

- Drug therapy – drug prescription
- Infarcts - ?

Current gets to the tip but the tip isn't where it should be

- lead has moved – CXR, diagnostic tests
- lead is perforated – CXR, Echo, diagnostic tests, CT....

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Busted leads – its all in the resistance

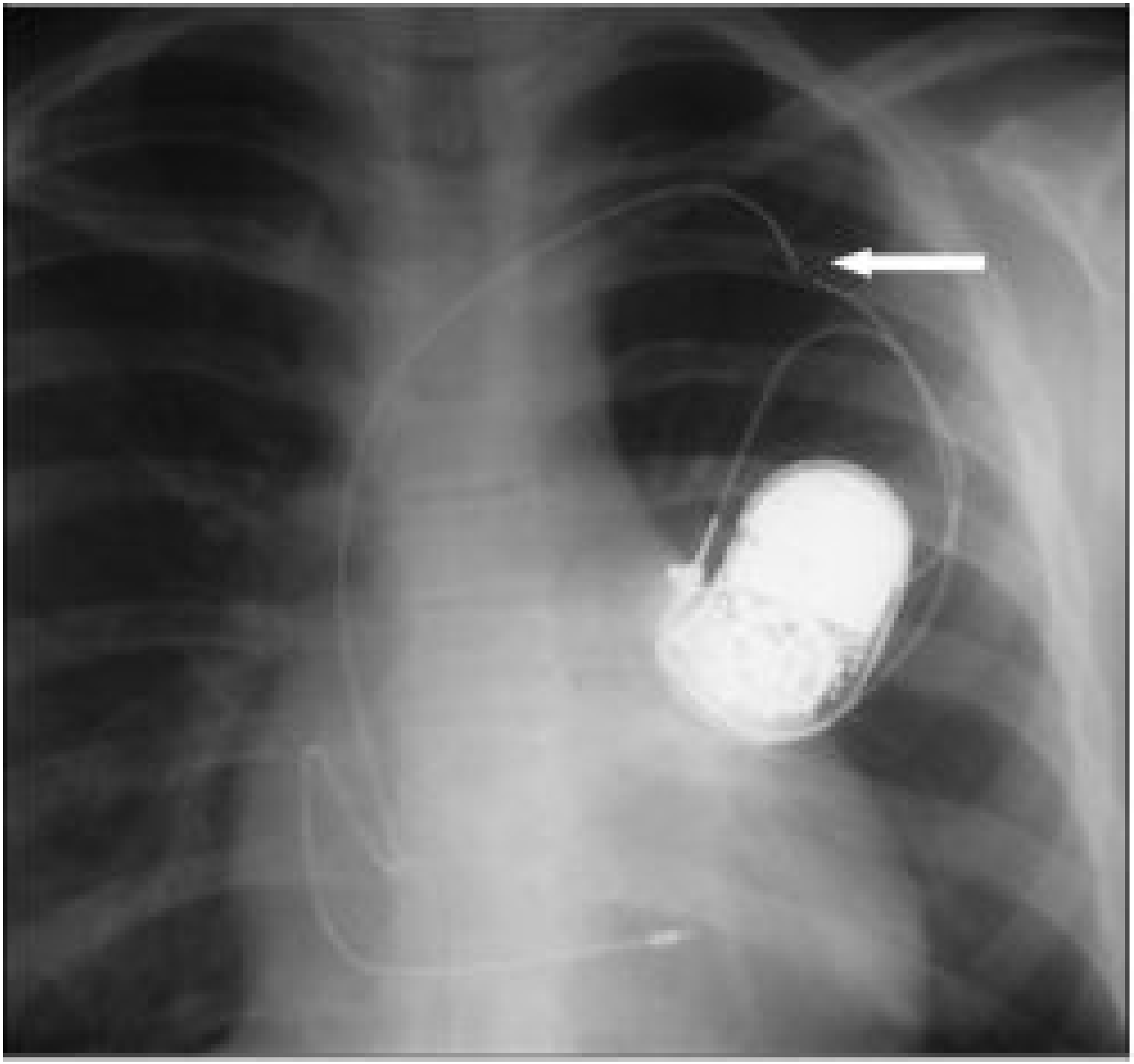
Flow of electricity = current

If you want “current” arriving at the end of the lead (hosepipe) you better not stand on the hose

A fractured lead = a stood on hose pipe

Altering impedance alters current/water flow

High Impedance = fractured lead



Low impedance

Flow of electricity = current

If you want current or water arriving at the end of the lead (hosepipe) you don't make holes in the hosepipe

A lead with insulation damage = a hosepipe with holes in it

Low Impedance = insulation damage – lower current at tip

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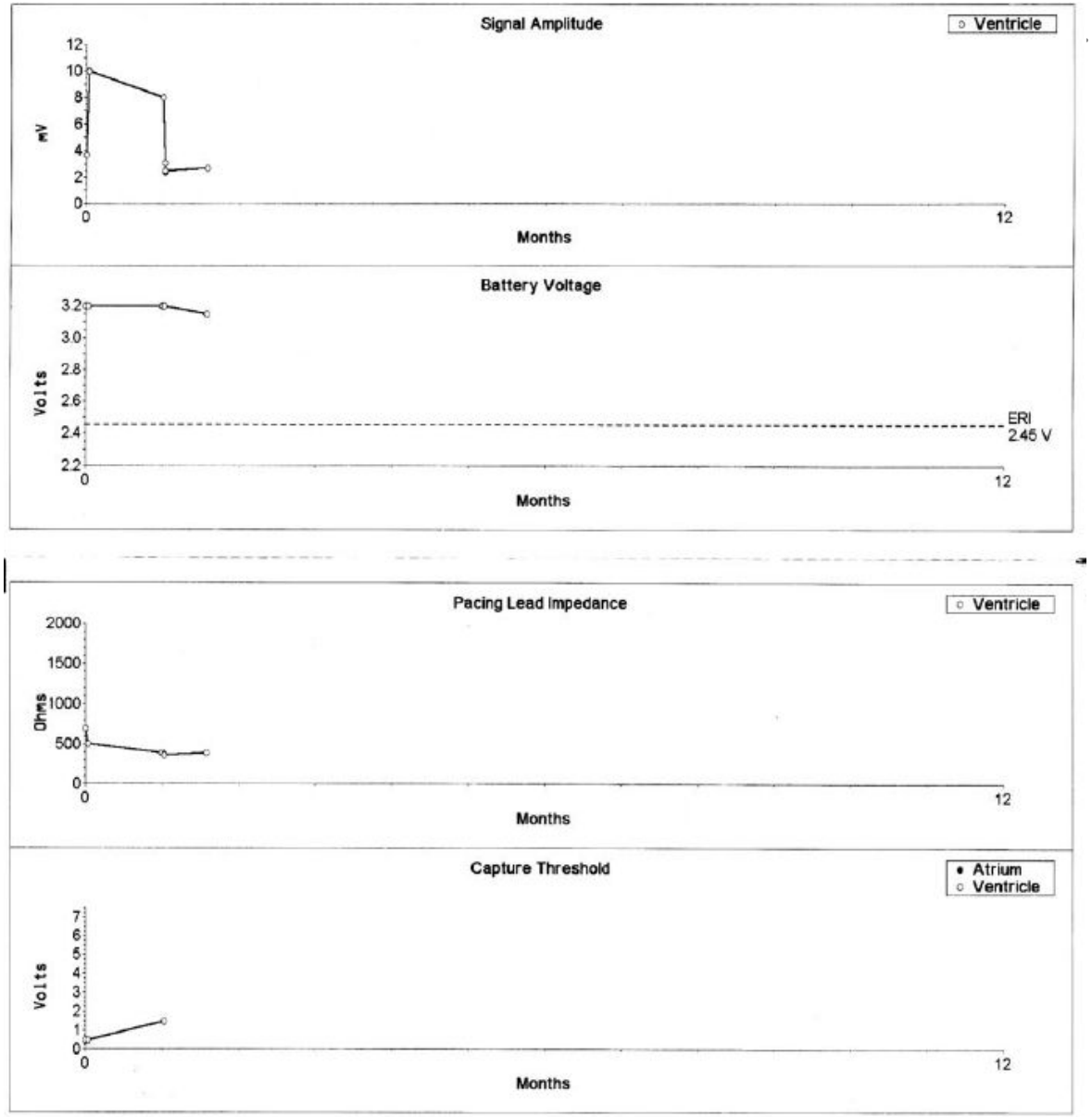
Follow-up
Rubble, Barney
Evia DR-T 66001352
65
A
V
I
A
V
Interrogation was successful.
PSA
Rate P 65 bpm
Rate R 65 bpm
AV del. 125 ms
Prog. Perm.
Follow-up
Parameters
Tests
Recordings
Diagnostics
Status
More
Preferences
Patient
Name Rubble, Barney
Last follow-up 28/11/2011
Date of implant 19/04/2010
Alerts and episodes
New episodes 0 record. available
Device status
Mode DDDR-ADIR
Basic rate/UTR [ppm] 60/200
Pulse amplitude A/V [V] 3.0 3.0
Pulse width A/V [ms] 0.4 0.4
Expected ERI 5 Y. 11 Mo.
90 %
EOS ERI
BOS
Test results A V
P/R wave amplitude [mV]
Threshold [V]
Lead impedance [Ohms] 448 468
TrendView
Diagnostics
Pacing in A/V [%] 100/100
Atrial burden [%] 0
Print
Help
Print manager
MRI
Start tests

What has gone wrong with this device?



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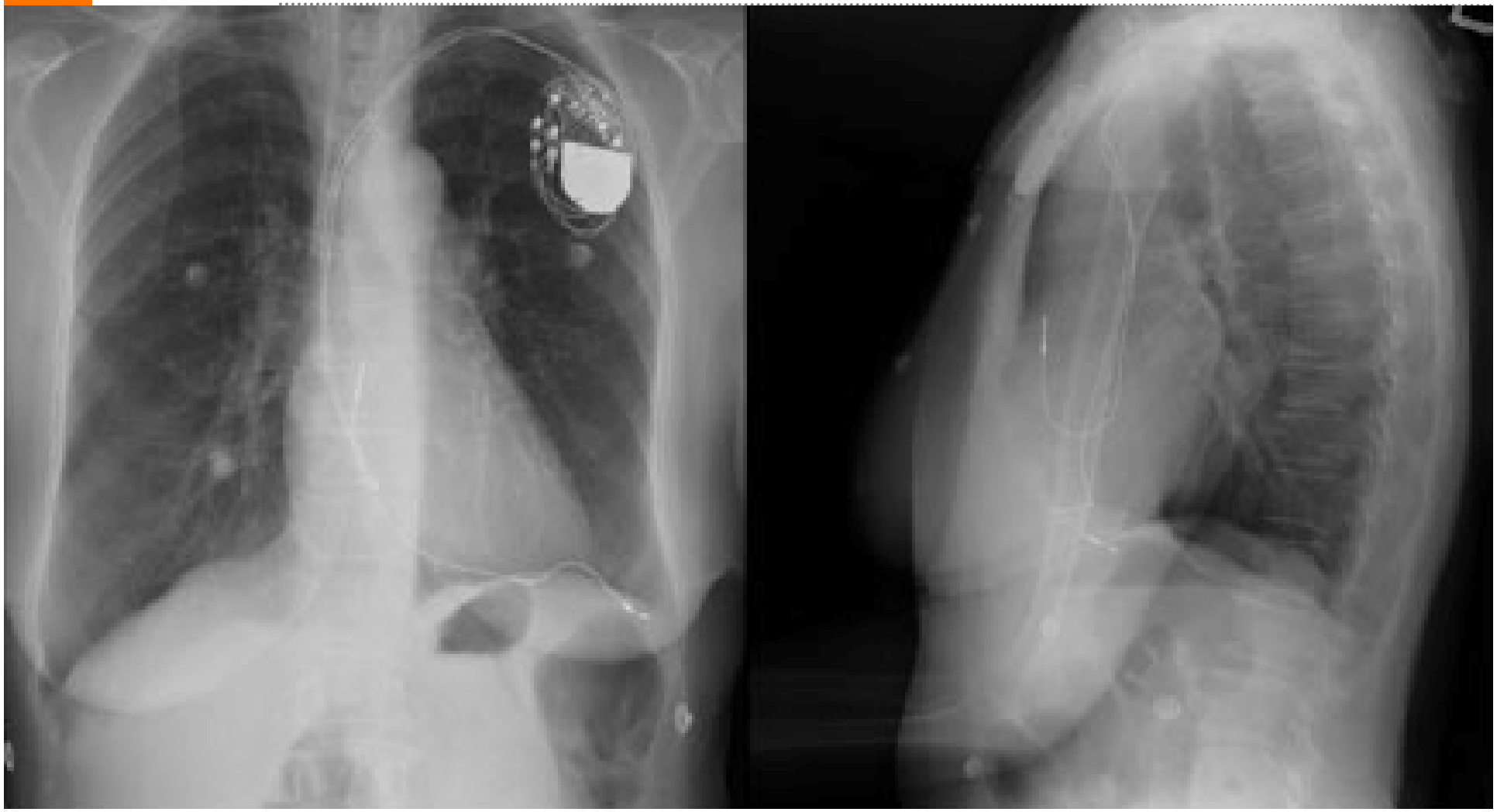

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Oversensing

Lead is bust

Lead is not where it should be

Something is not programmed correctly

The lead is touching something it should not be

Lead was the wrong lead for that patient

Something from the outside world

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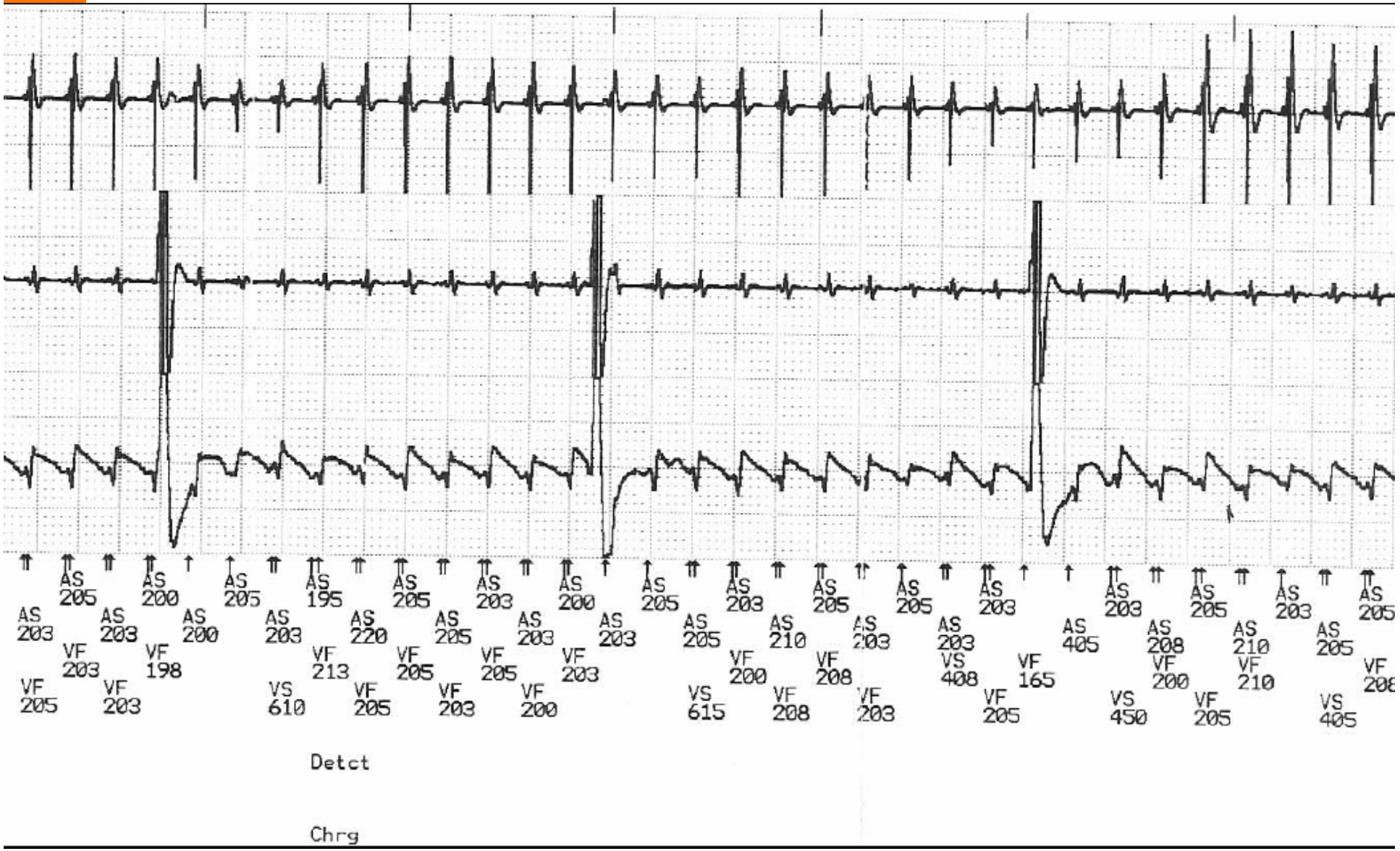
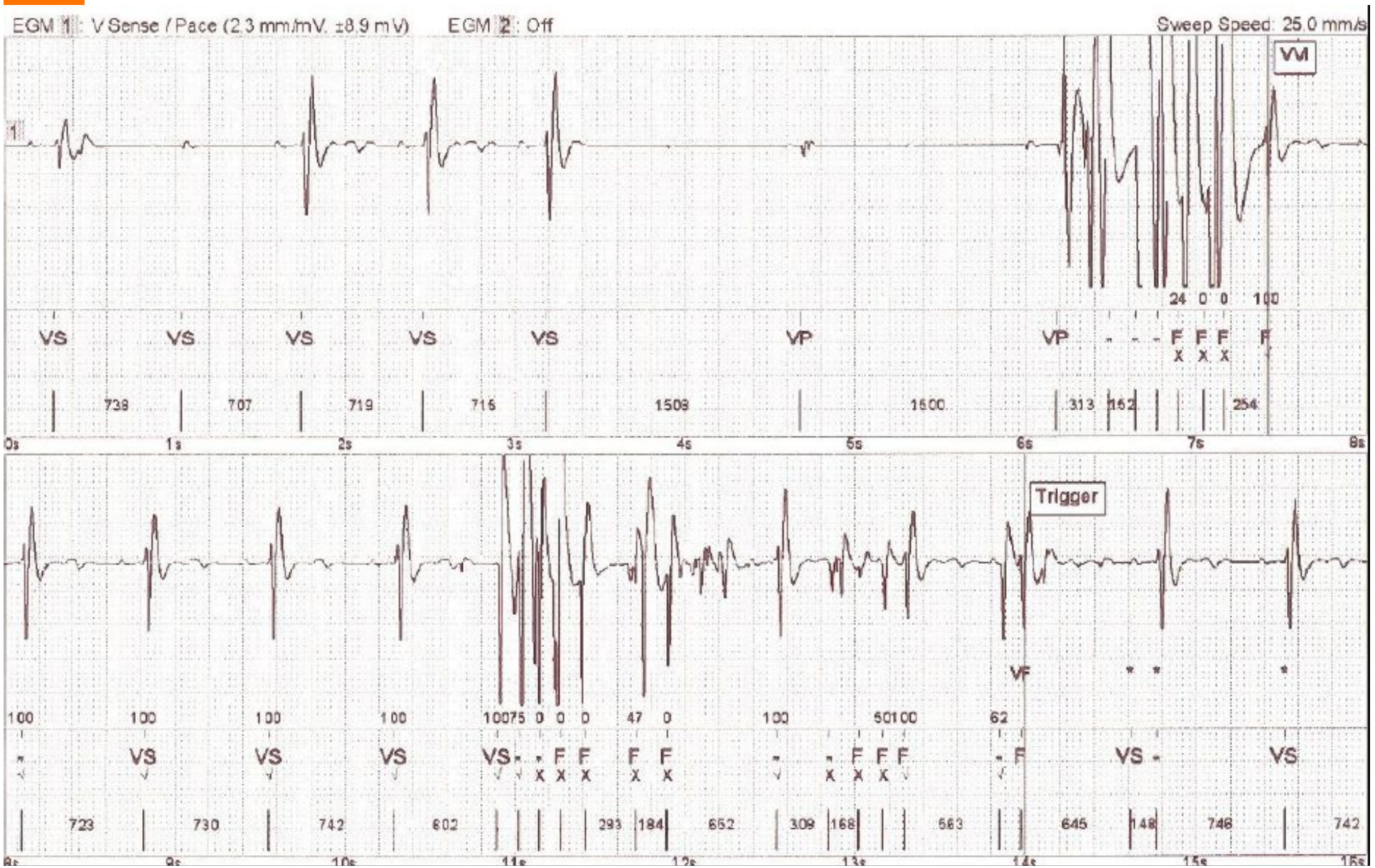
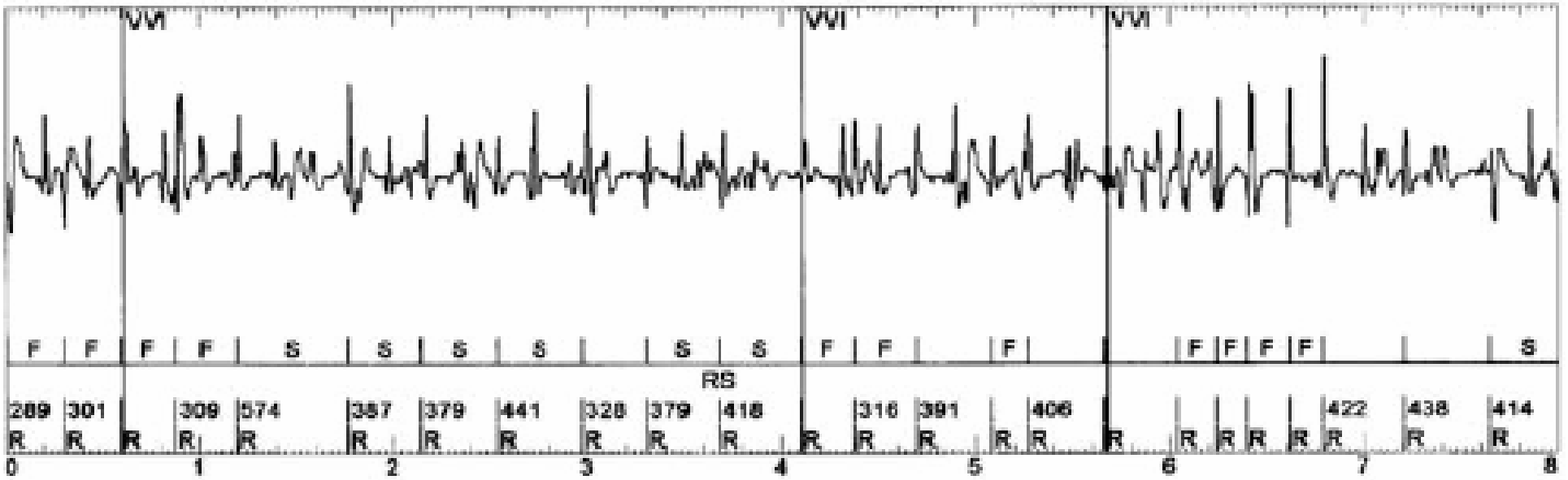
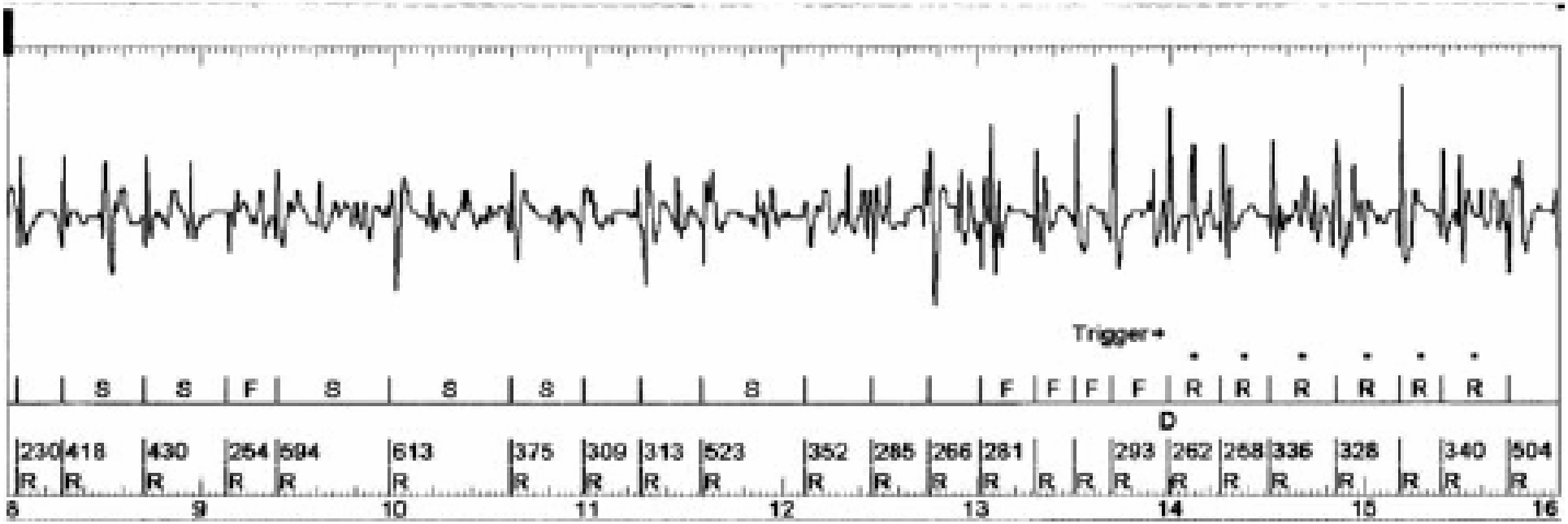
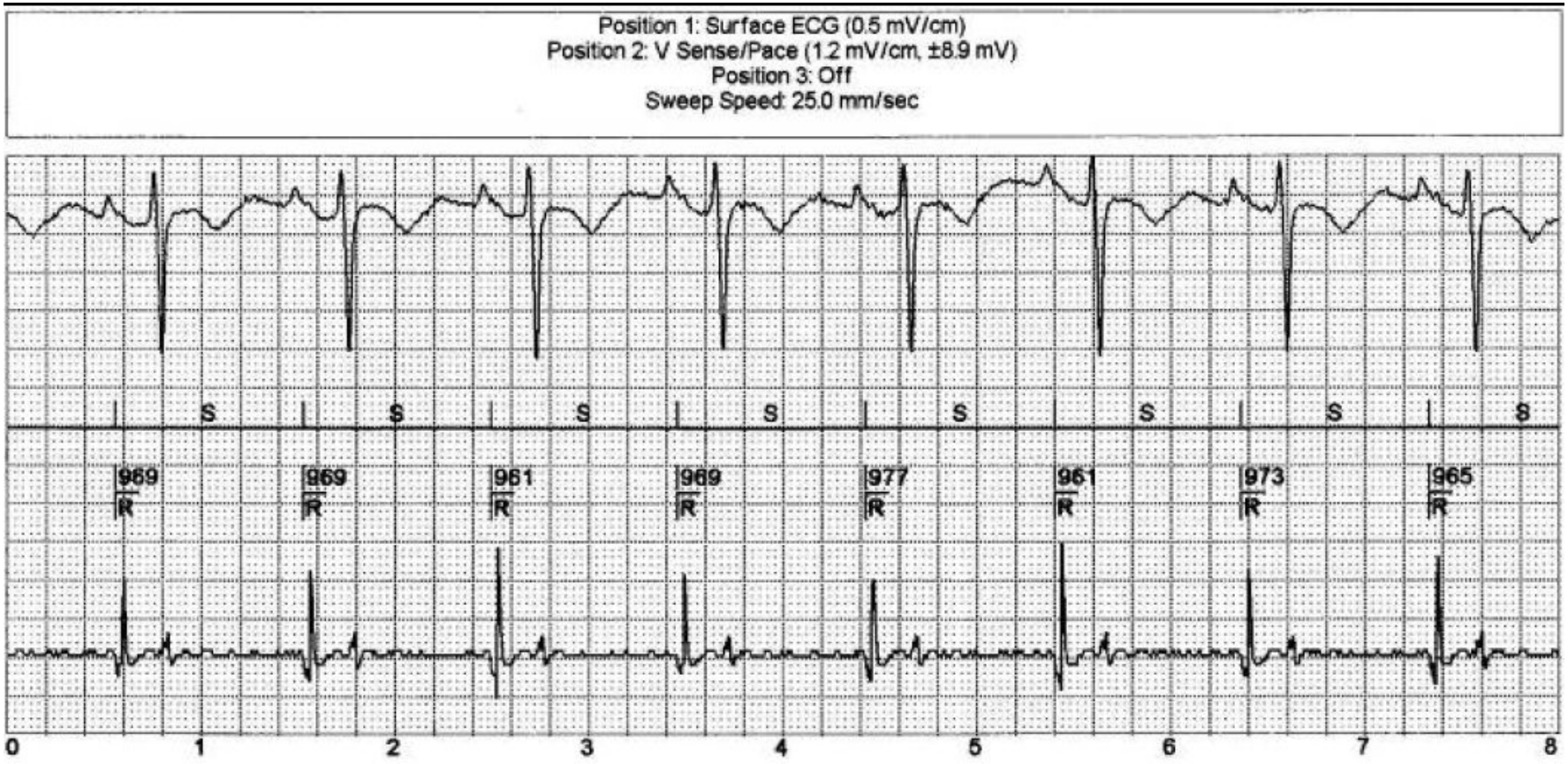

AS 205 AS 200 AS 205 AS 195 AS 205 AS 203 AS 200 AS 205 AS 203 AS 205 AS 205 AS 203 AS 203 AS 205 AS 203 AS 205
AS 203 AS 203 AS 200 AS 203 AS 220 AS 205 AS 203 AS 203 AS 205 AS 210 AS 203 AS 203 AS 405 AS 208 AS 210 AS 205
VF 203 VF 198 VF 213 VF 205 VF 205 VF 203 VF 200 VF 208 VS 408 VF 165 VF 200 VF 210 VF 208
VF 205 VF 203 VS 610 VF 205 VF 203 VF 200 VS 615 VF 208 VF 203 VF 205 VS 450 VF 205 VS 405
Detct
Chrg


EGM 1: V Sense / Pace (2.3 mm/mV, ±8.9 mV)
EGM 2: Off
Sweep Speed: 25.0 mm/s
VVI
VS VS VS VS VS VP VP F F F F
738 707 719 716 1509 1500 313 162 254
0s 1s 2s 3s 4s 5s 6s 7s 8s
Trigger
VF
VS VS VS VS VS VS
723 730 742 602 293 184 652 309 168 563 645 148 748 742
9s 10s 11s 12s 13s 14s 15s 16s


VVI
VVI
VVI
F F F F S S S S S S F F F F F F F S
RS
289 301 309 574 387 379 441 328 379 418 316 391 406 422 438 414
R R R R R R R R R R R R R R R R R R R R R R
0 1 2 3 4 5 6 7 8


Trigger
S S F S S S S F F F F R R R R R R
D
230 418 430 254 594 613 375 309 313 523 352 285 266 281 293 262 268 336 328 340 504
R R R R R R R R R R R R R R R R R R R R R
8 9 10 11 12 13 14 15 16



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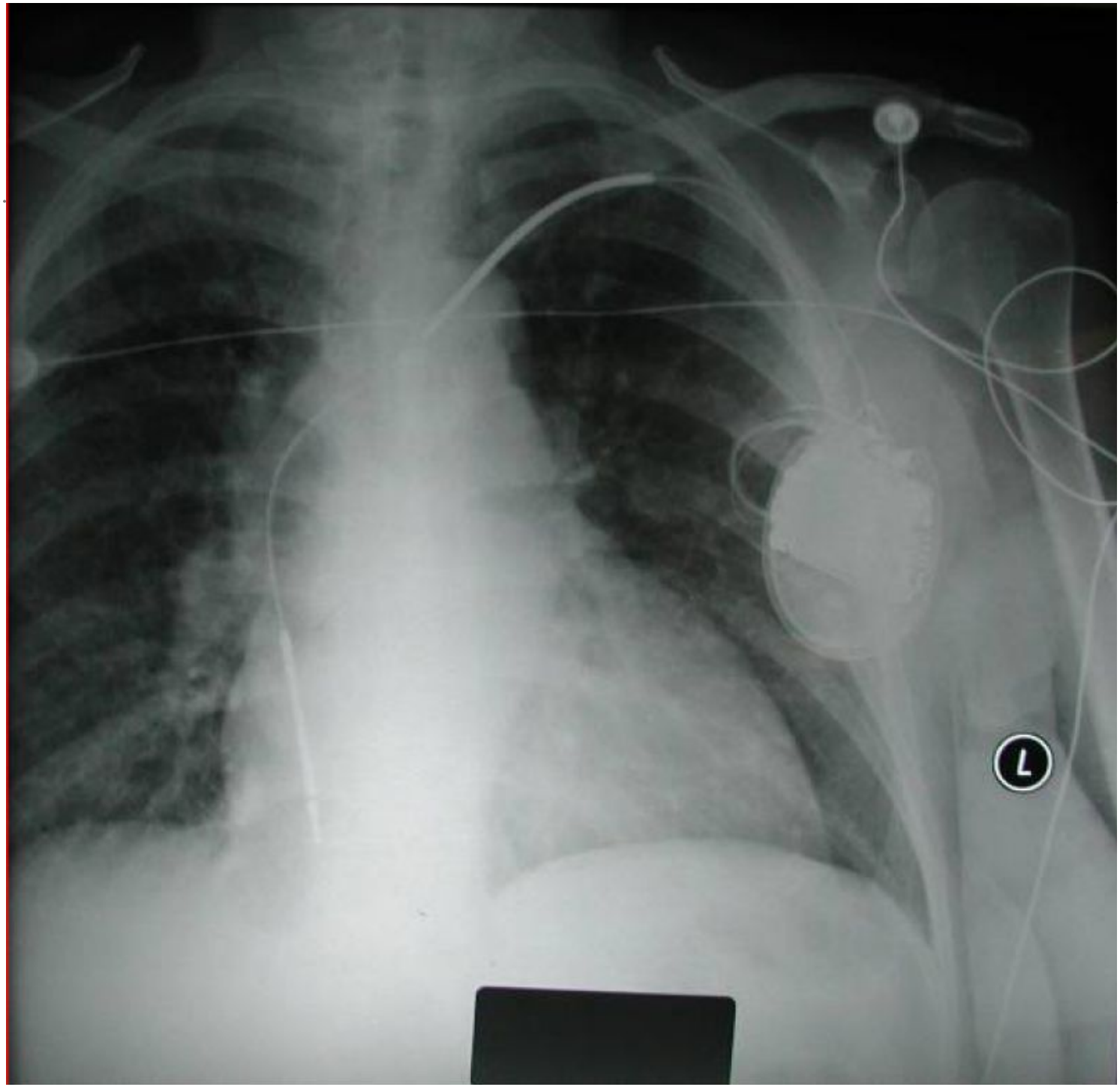
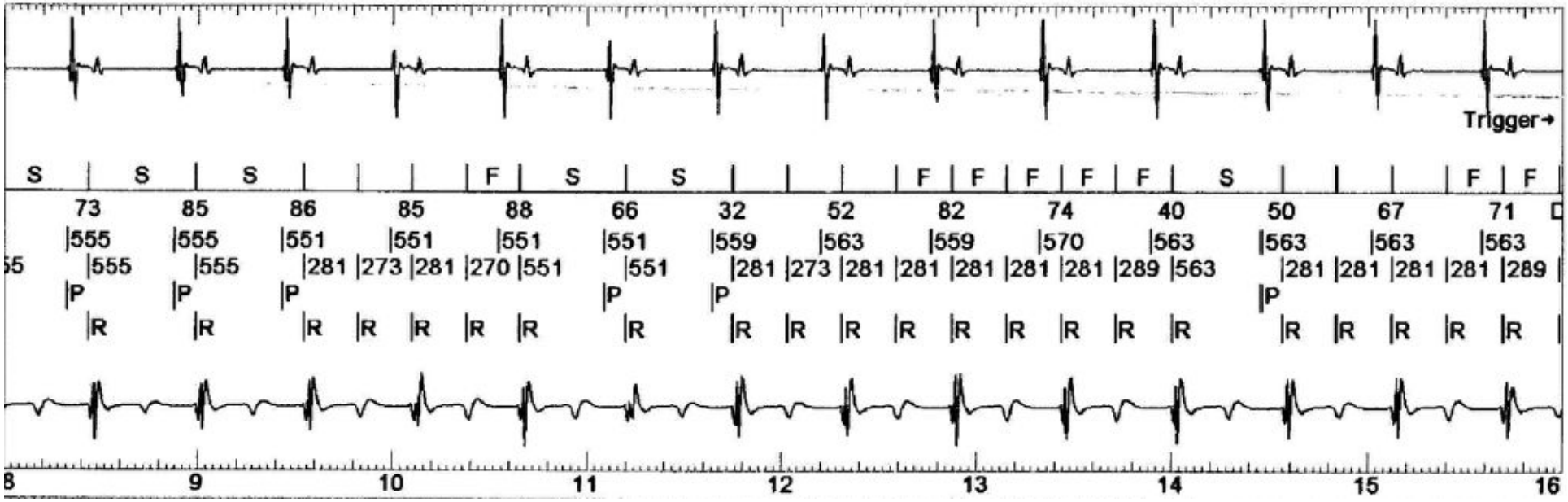
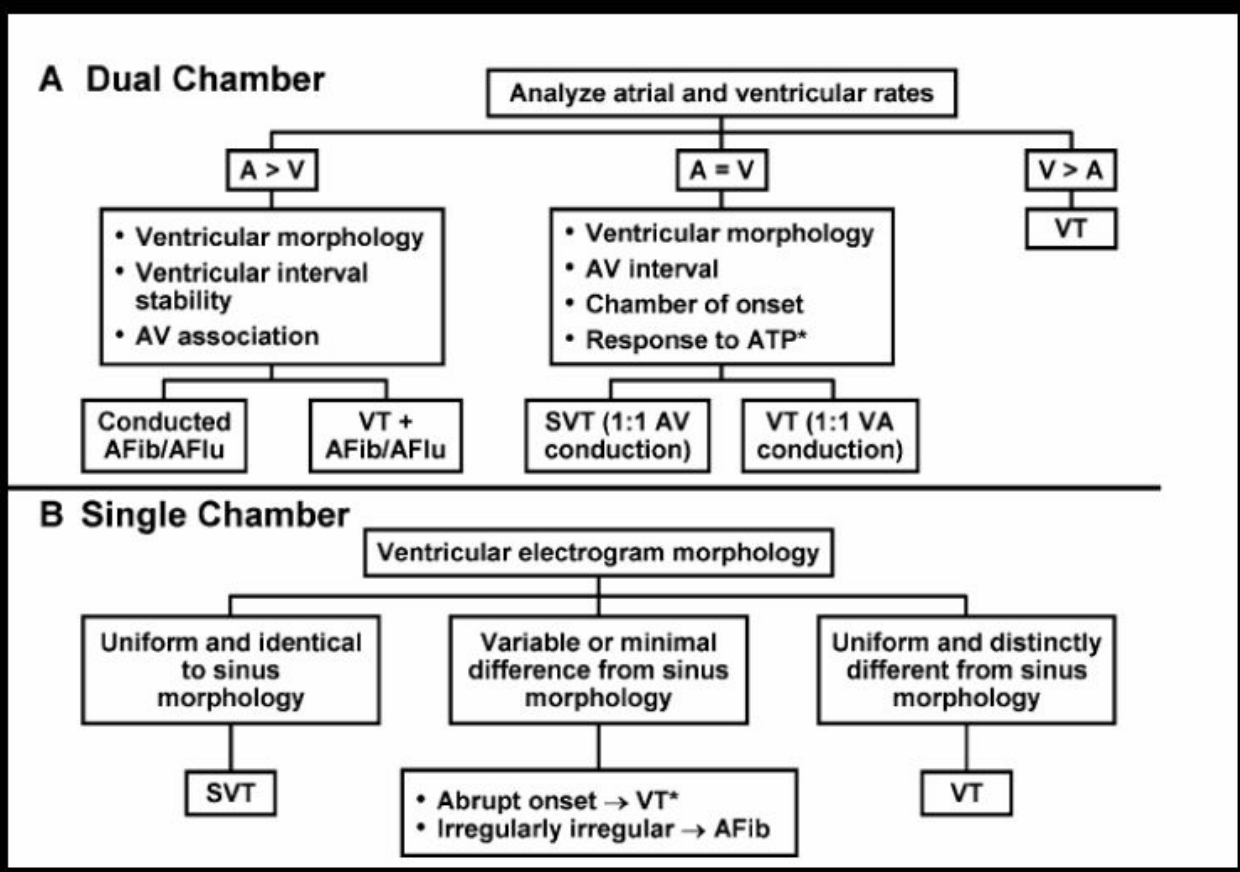
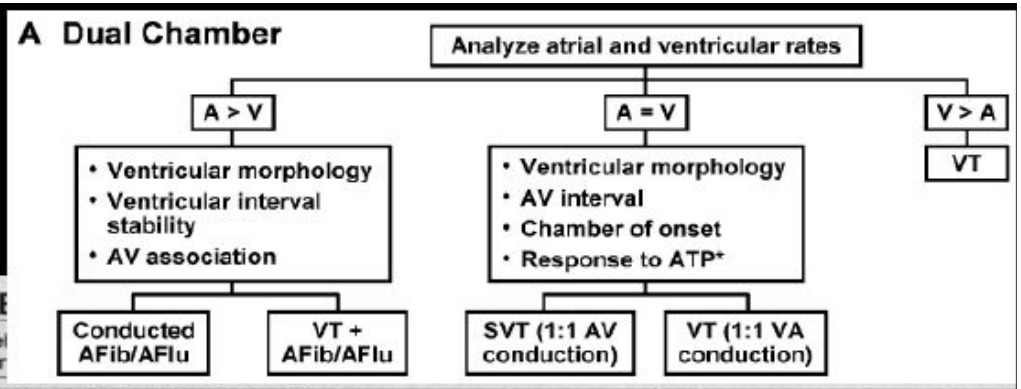

L


Trigger→
S S S F S S F F F F F S F F
73 85 86 85 88 66 32 52 82 74 40 50 67 71
|555 |555 |551 |551 |551 |551 |559 |563 |559 |570 |563 |563 |563 |563
|555 |555 |281 |273 |281 |270 |551 |551 |281 |273 |281 |281 |281 |281 |281 |289 |563 |281 |281 |281 |281 |289
|P |P |P |P |P |P
|R |R |R |

An Algorithm



Easy



ST. JUDE MEDICAL

Stored E

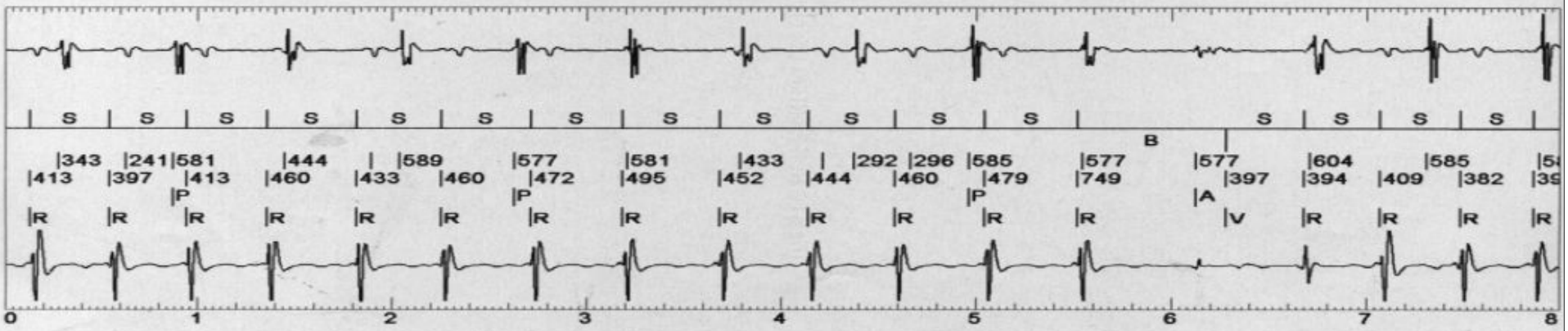
Patient

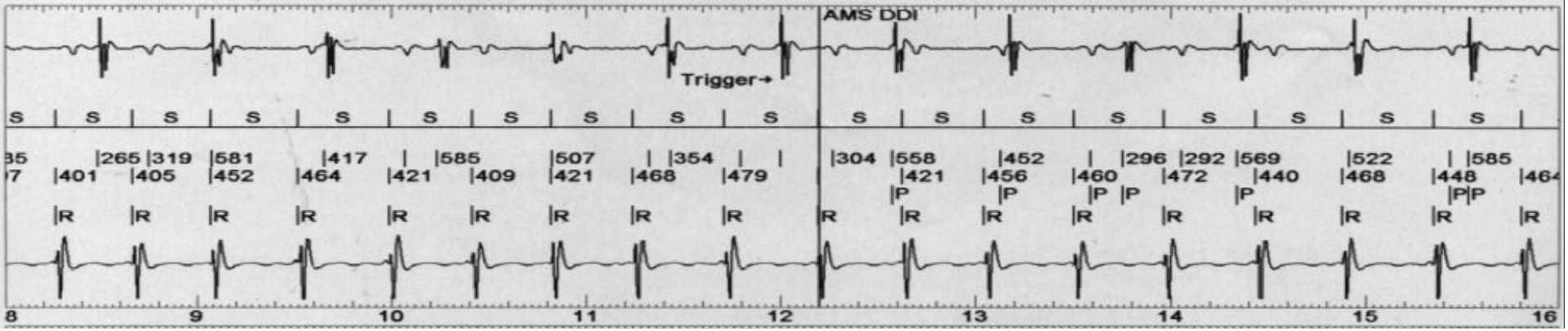
EGM 2: (0-17 sec)

Photon™ DR Model

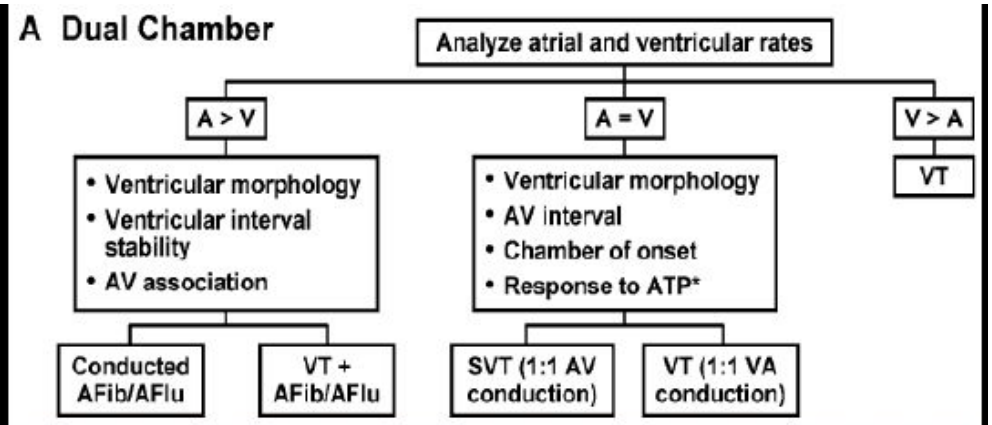
Summary : Entr

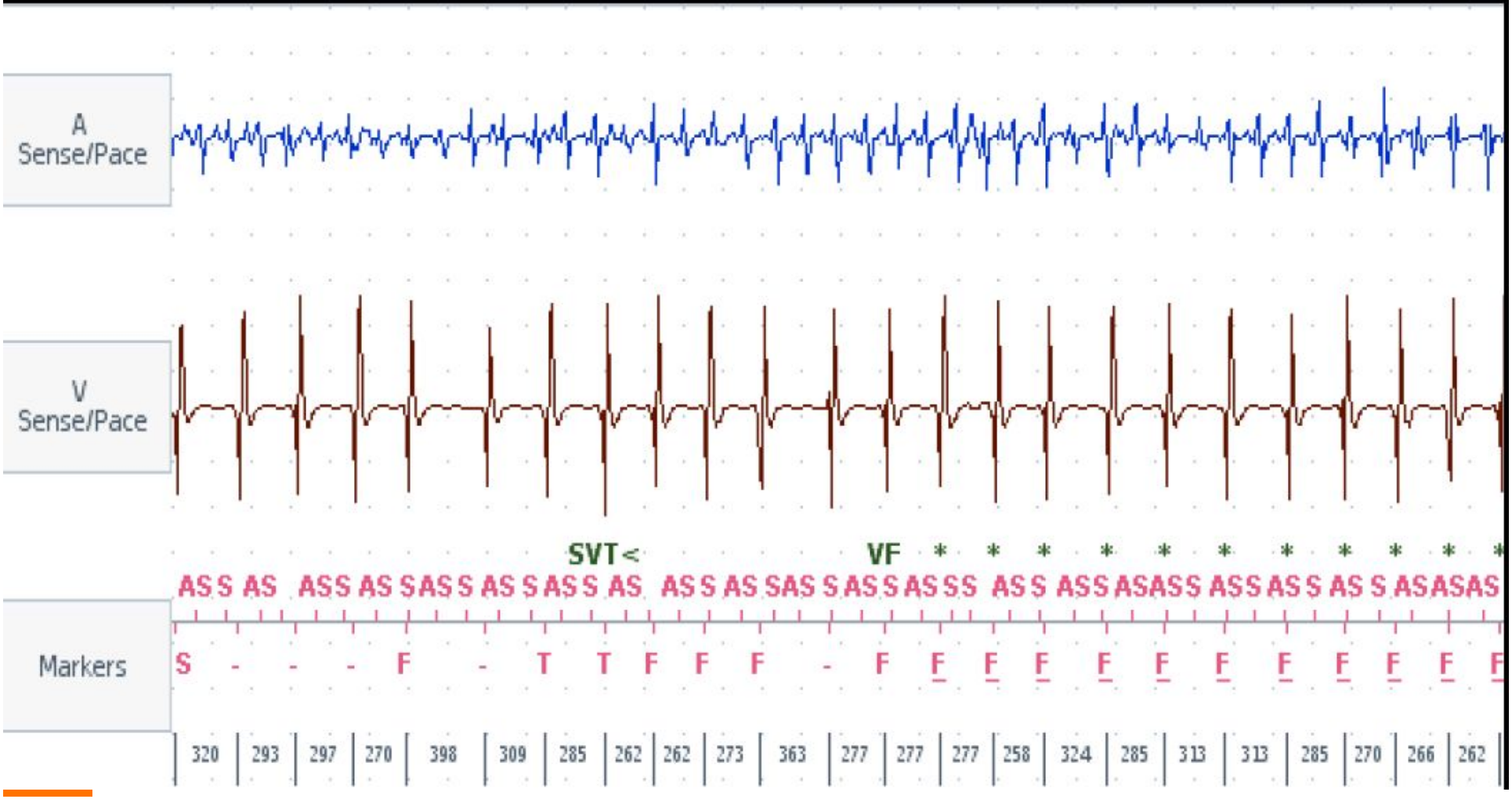
Position 1: A Sense/Pace (1,4 mV/cm, ±3,0 mV)
Position 2: V Sense/Pace (12,5 mV/cm, ±8,9 mV)
Sweep Speed: 25,0 mm/sec



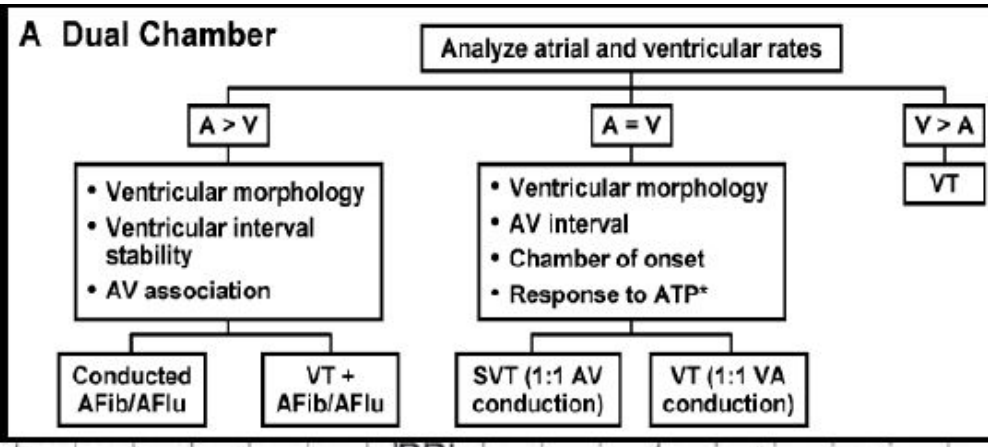


Easier…


A Dual Chamber
Analyze atrial and ventricular rates
A > V
A = V
V > A
• Ventricular morphology
• Ventricular interval stability
• AV association
• Ventricular morphology
• AV interval
• Chamber of onset
• Response to ATP*
VT
Conducted AFib/AFlu
VT + AFib/AFlu
SVT (1:1 AV conduction)
VT (1:1 VA conduction)


A Sense/Pace
V Sense/Pace
SVT<
VF
Markers
320 293 297 270 398 309 285 262 262 273 363 277 277 277 258 324 285 313 313 285 270 266 262

Bit harder…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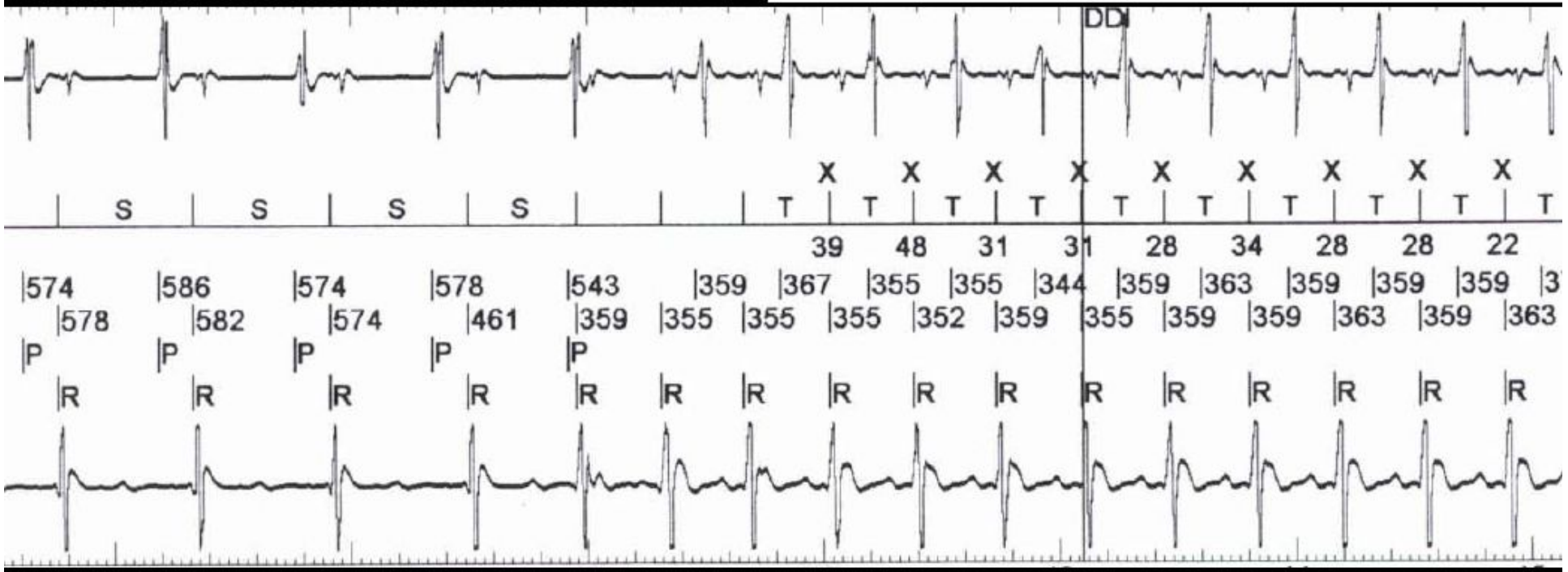
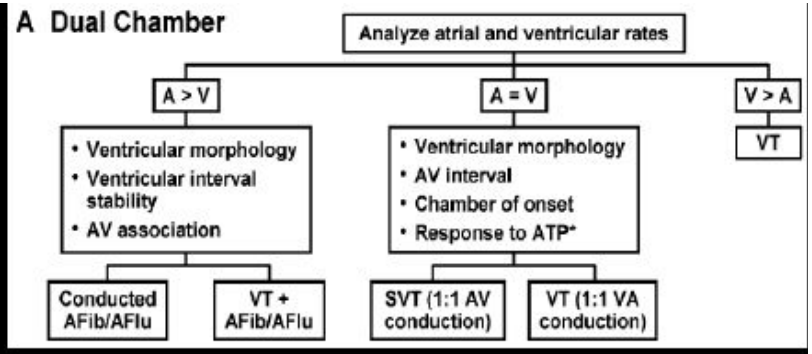
Conducted AFib/AFlu
VT + AFib/AFlu
SVT (1:1 AV conduction)
VT (1:1 VA conduction)


DDI
S S S S
X X X X X X X X X X
T T T T T T T T T T T
39 48 31 31 28 34 28 28 22
574 586 574 578 543 359 367 355 355 344 359 363 359 359 359
578 582 574 461 359 355 355 355 352 359 355 359 359 363 359 363
P P P P P
R R R R R R R R R R R R R R R R R R

Not so tough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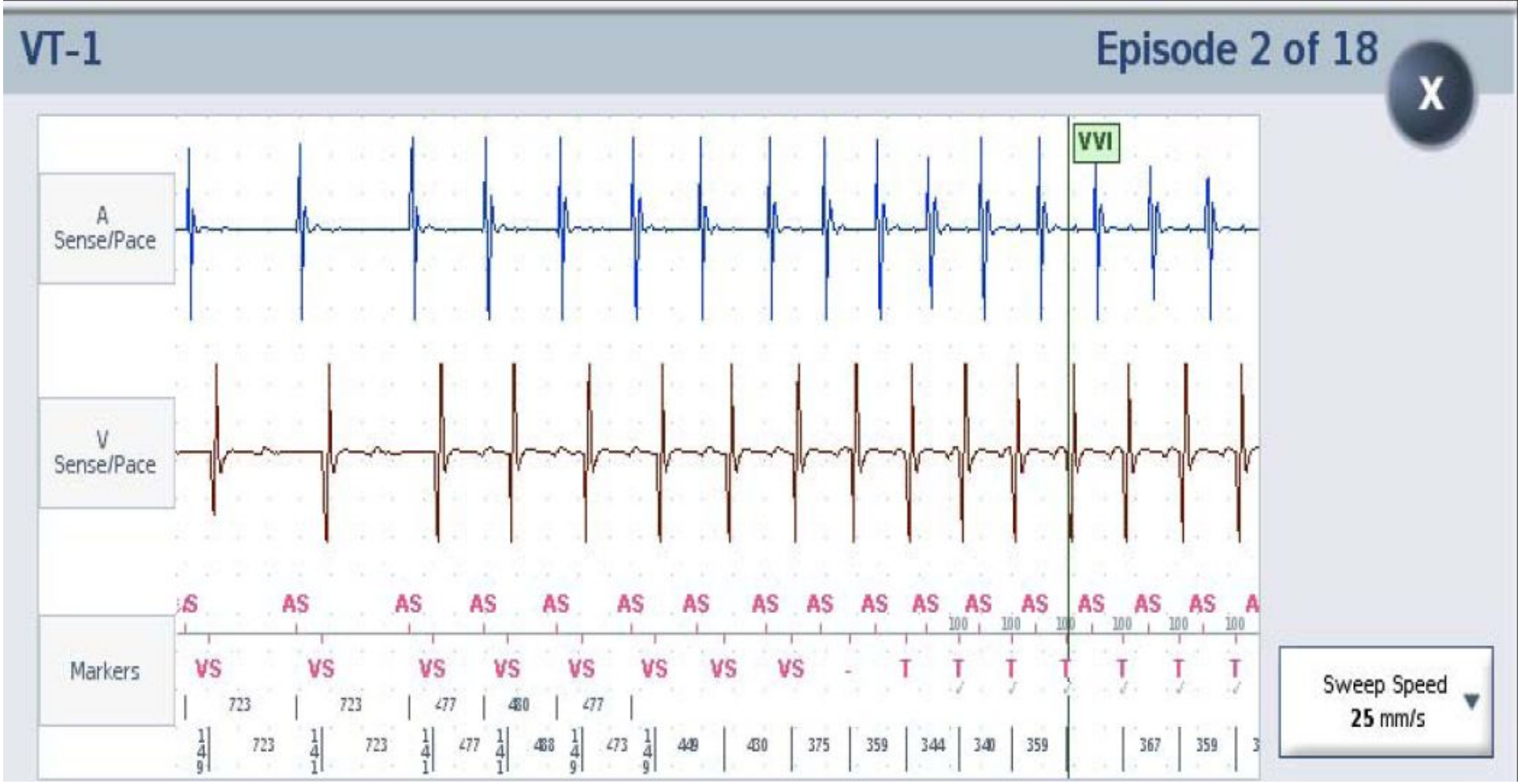
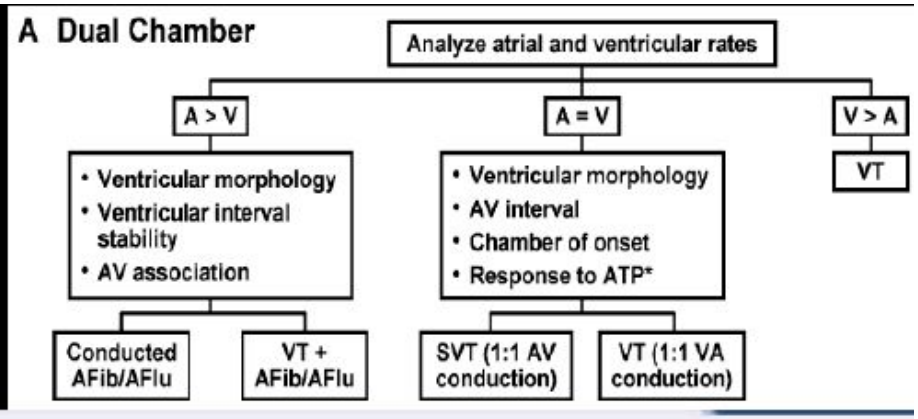
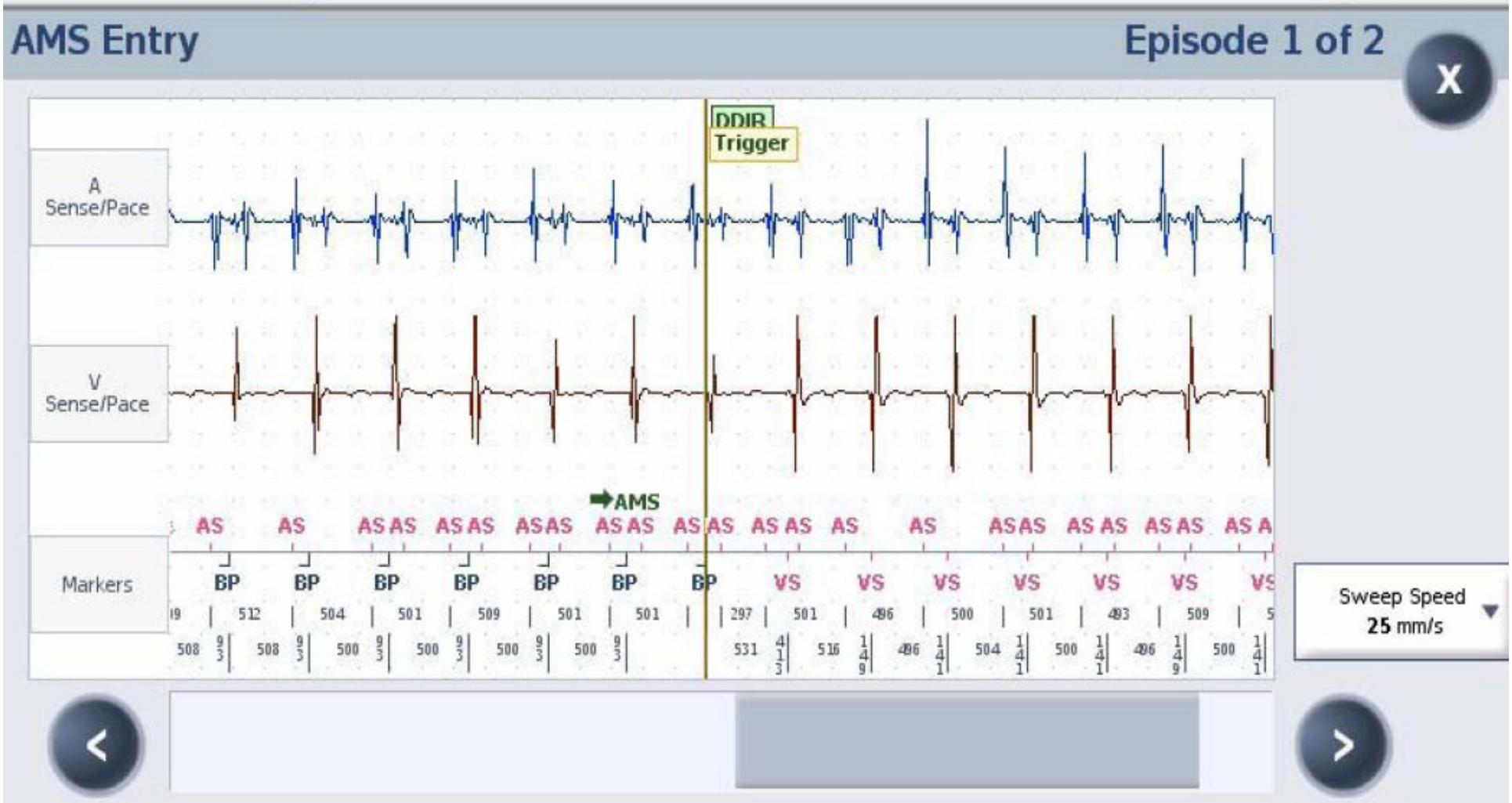
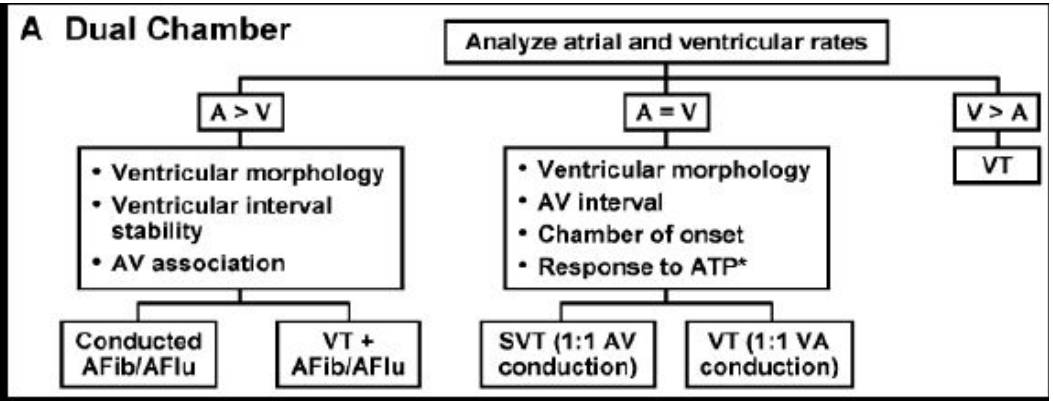

VT-1
Episode 2 of 18
X
VVI
A Sense/Pace
V Sense/Pace
Markers
AS
VS
T
Sweep Speed
25 mm/s

Bit harder still….





Easy?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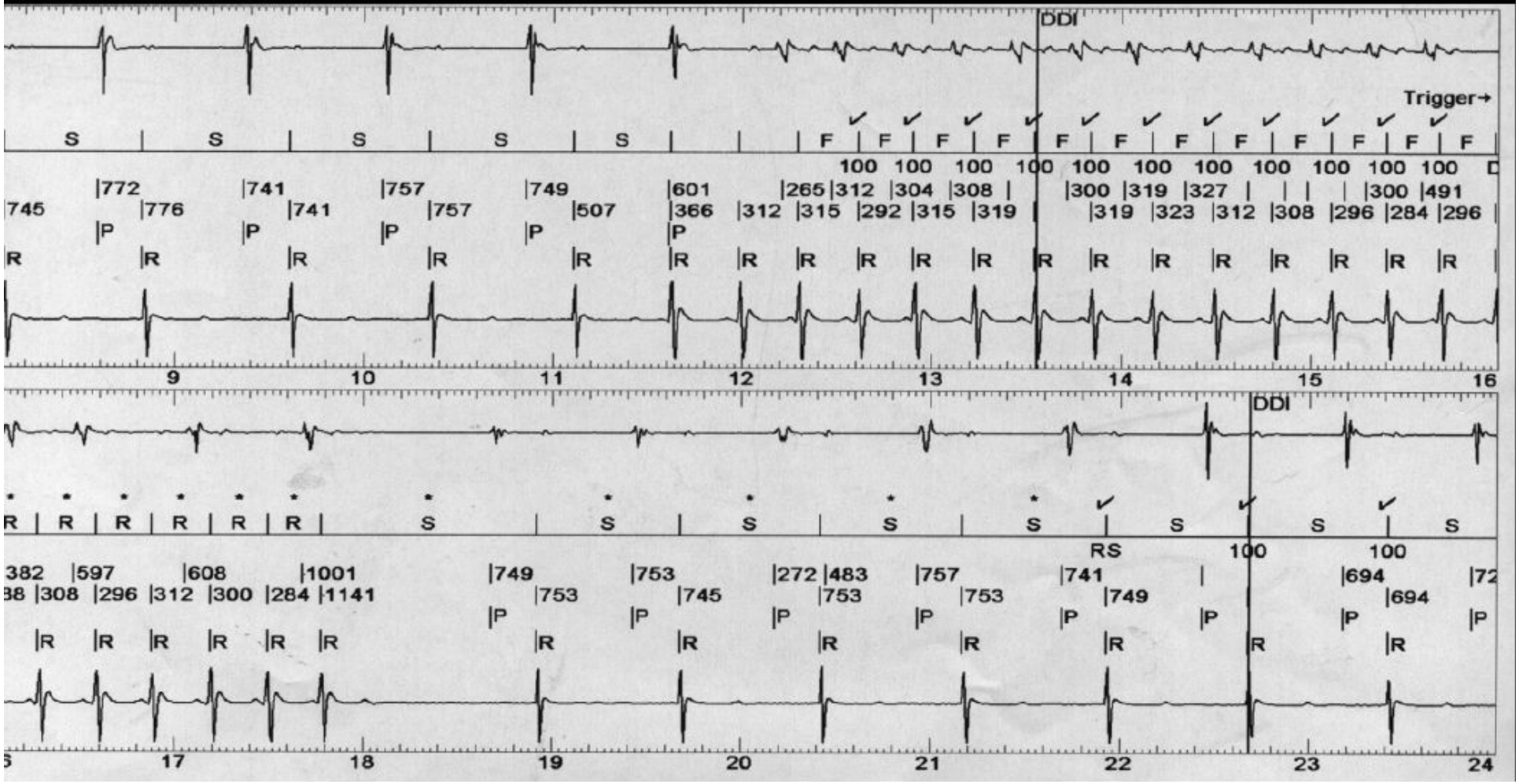
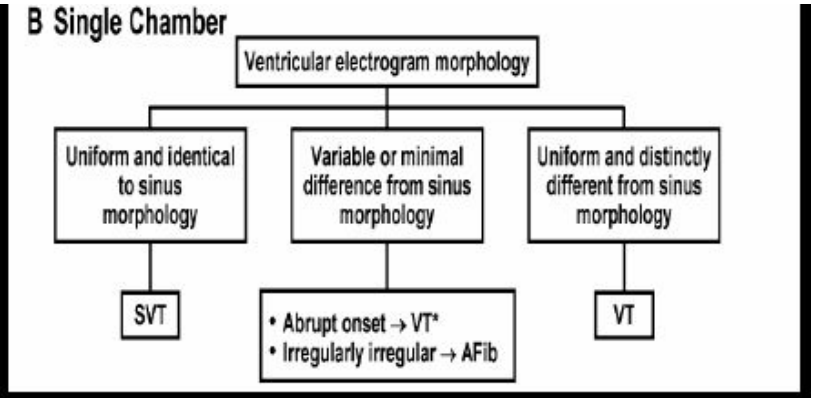
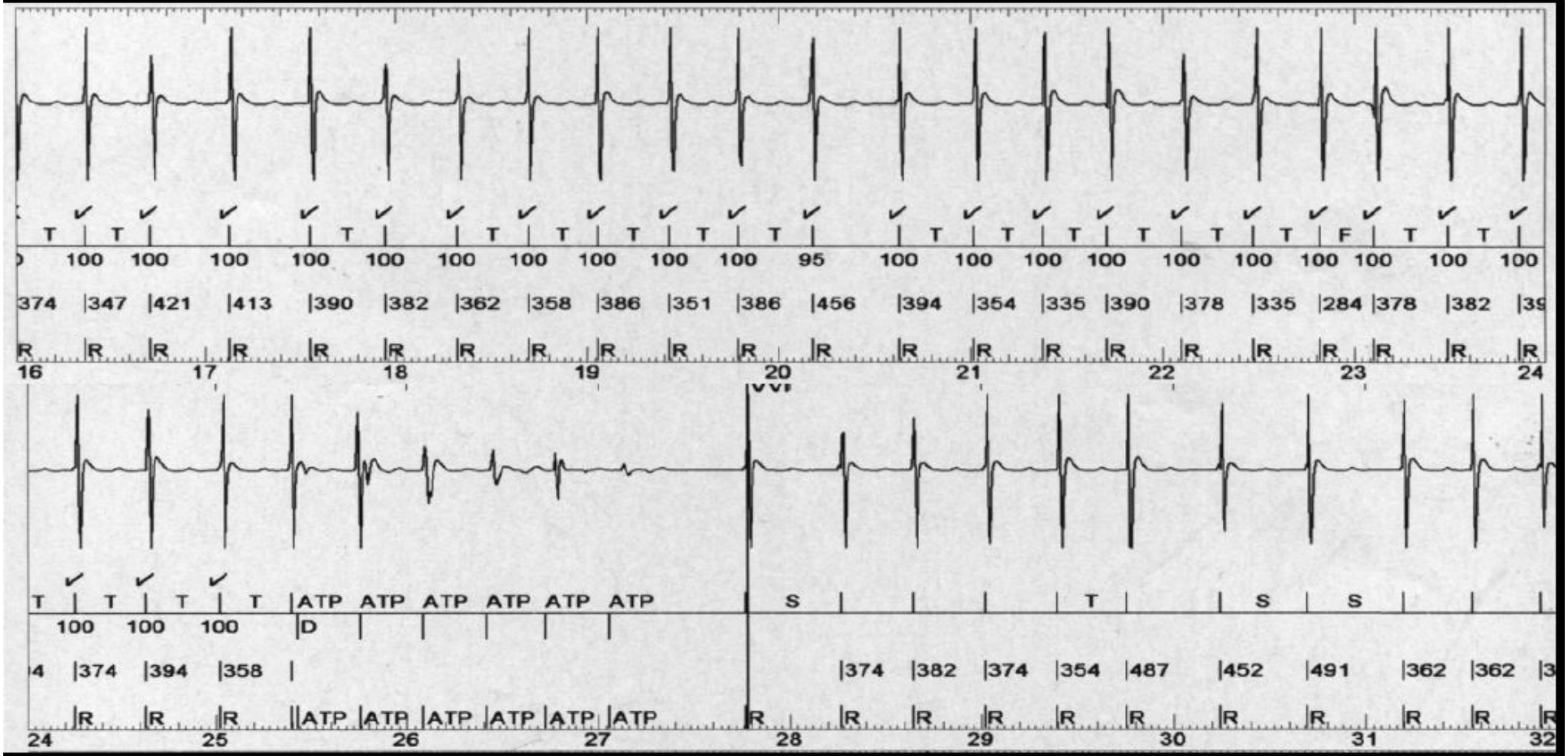

DDI
Trigger→
DDI

Very, very easy




T T T

Lack of appropriate Rx or unsuccessful Rx

Loss of CRT pacing

- AF, bad programming, weird stuff

Unsuccessful ATP

- MVT success = ?% – is it really VT?

Unsuccessful shocks

- Is the circuit OK – what is the impedance?
- More commonly seen at implantation

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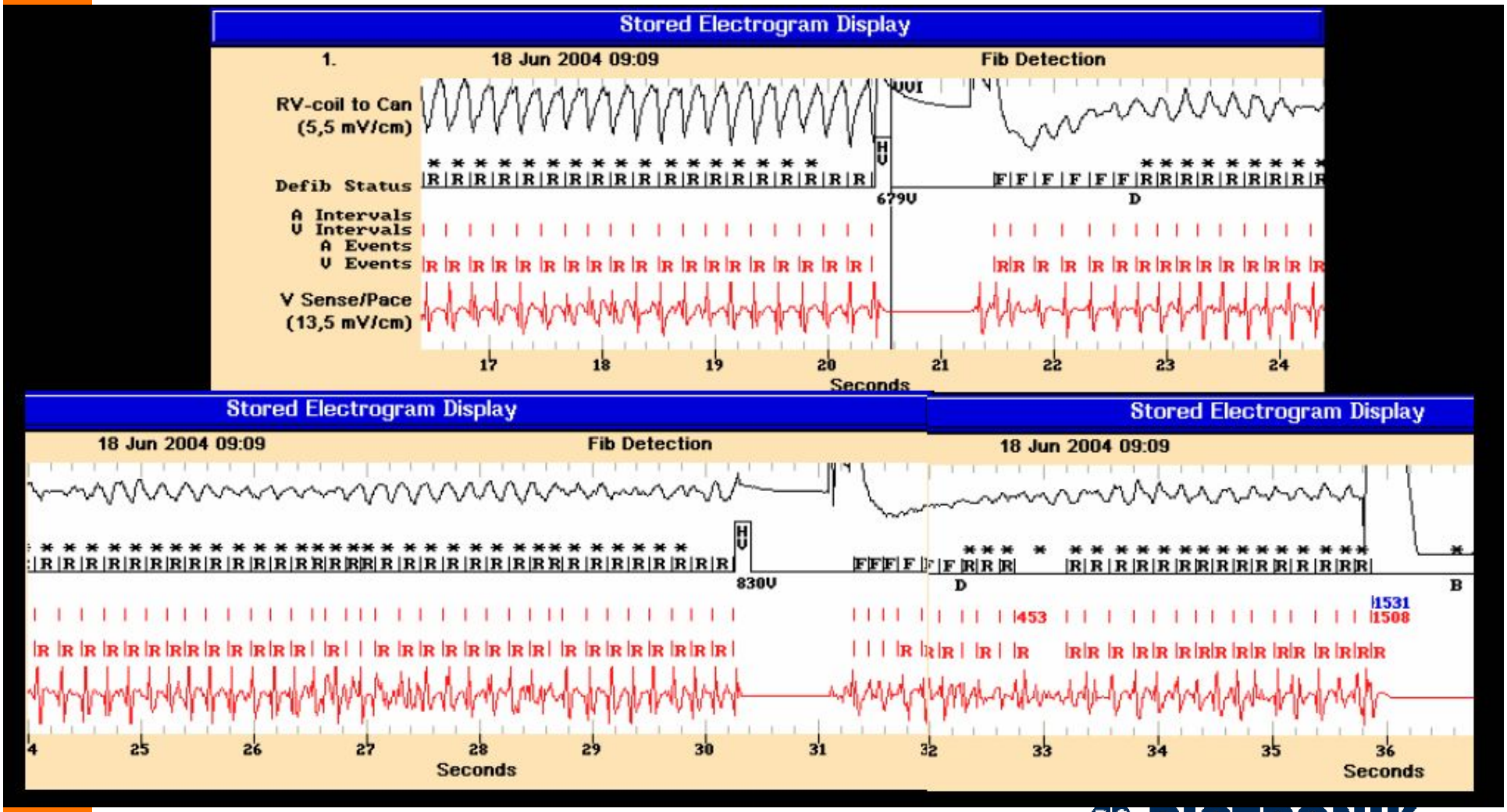
Implant induction & failure



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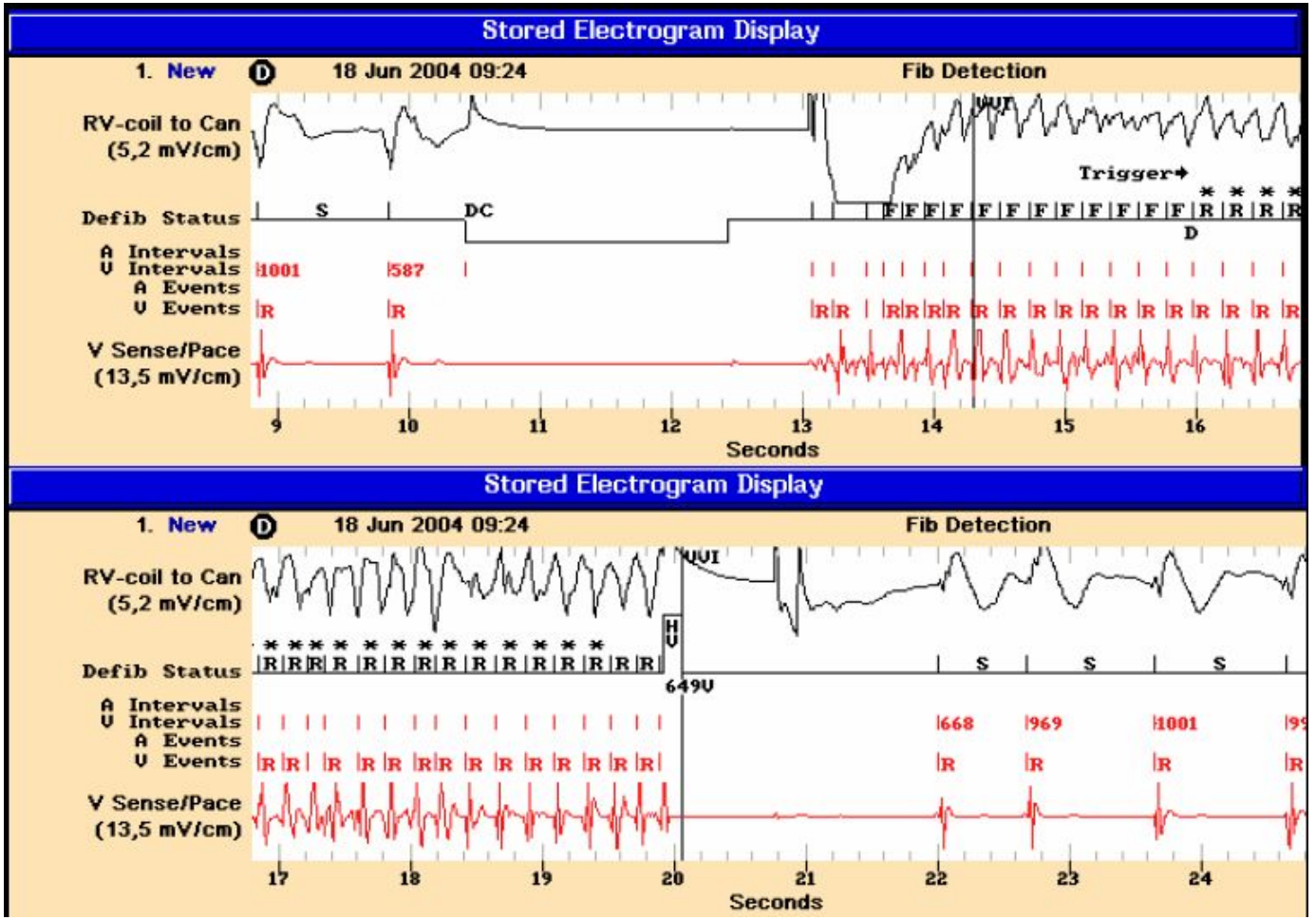
Less energy – more success!



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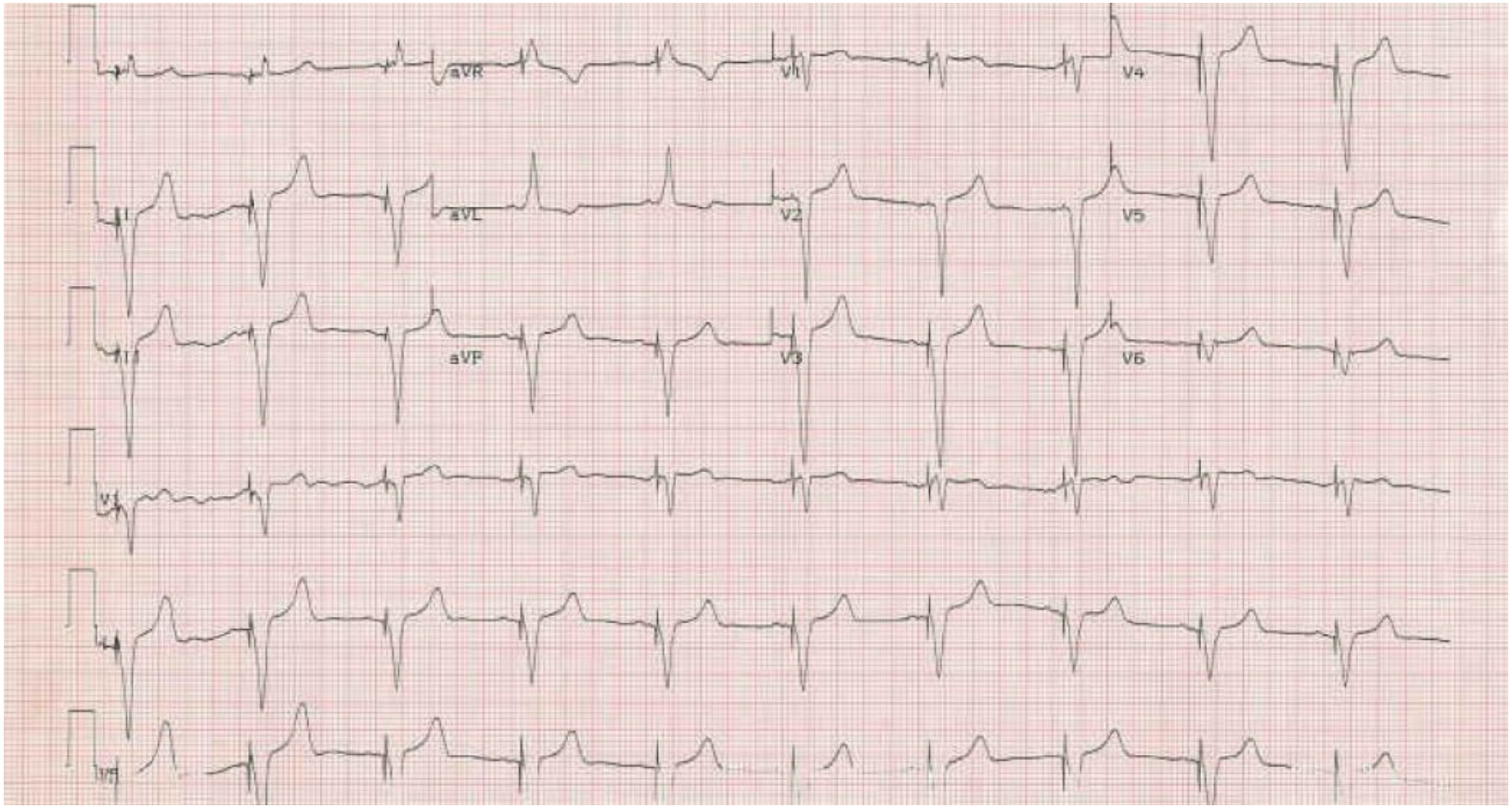
LV pacing threshold……?



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Idiosyncratic stuff – the unknown unknowns...

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37yr old, LQT, mute, deaf...

ARAMETER SUMMARY REPORT ---------- Page 1 of 1

atient Name _____

herapy	VF 200-500 bpm
1	DEFIB 20J
2	DEFIB 30J
3	DEFIB 30J
4	DEFIB 30J
5	DEFIB 30J
6	DEFIB 30J

rady Pacing is VVI: Rate(ppm) = 40, Hysteresis(bpm) = OFF.

PARAMETER SETTINGS REPORT ---------- Page 1 of 4

	ENABLE	INTERVAL
VF	ON	300 ms
FVT	OFF	ms
VT	OFF	400 ms

	NID INITIAL	NID REDETECT
VF	24/32	12/16
VT	16	16

Sensitivity(mV): 0.3

ADDITIONAL VT DETECTION CRITERIA

STABILITY	OFF
ONSET	OFF
EGM WIDTH	OFF

EGM Source: HVA to HVB EGM Range(mV): ±7.5

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Device settings

PARAMETER SETTINGS REPORT ---------- Page 2 of 4

VF THERAPY:	1	2	3	4	5	6
VF Therapy Status:	ON	ON	ON	ON	ON	ON
Energy(J):	20	30	30	30	30	30
Waveform:	BIPH	BIPH	BIPH	BIPH	BIPH	BIPH
Pathway:	AX>B	AX>B	AX>B	AX>B	B>AX	AX>B

Reconfirm VF After Initial Charge: YES

FVT THERAPY:	1	2	3	4	5	6
FVT Therapy Status:						
Therapy Type:	NONE	NONE	NONE	NONE	NONE	NONE
Initial # Pulses:						
R-S1 Interval=(%RR):						
S1S2(RAMP+)=(%RR):						
S2SN(RAMP+)=(%RR):						
Interval Dec (ms):						
# Sequences:						
Smart Mode:						
Energy(J):						
Waveform:						
Pathway:						

Anti-Tachy Pacing Minimum Interval (ms): 200

PARAMETER SETTINGS REPORT ---------- Page 3 of 4

VT THERAPY:	1	2	3	4	5	6
VT Therapy Status:						
Therapy Type:	NONE	NONE	NONE	NONE	NONE	NONE
Initial # Pulses:						
R-S1 Interval=(%RR):						
S1S2(RAMP+)=(%RR):						
S2SN(RAMP+)=(%RR):						
Interval Dec (ms):						
# Sequences:						
Smart Mode:						
Energy(J):						
Waveform:						
Pathway:						

Anti-Tachy Pacing Minimum Interval (ms): 200

SHARED ANTI-TACHY PACING THERAPY:		SHARED CV THERAPY:	
Pulse Width(ms):	1.6	CV Delay(ms):	0
Amplitude(V):	8.0		
Pace Blanking(ms):	320		

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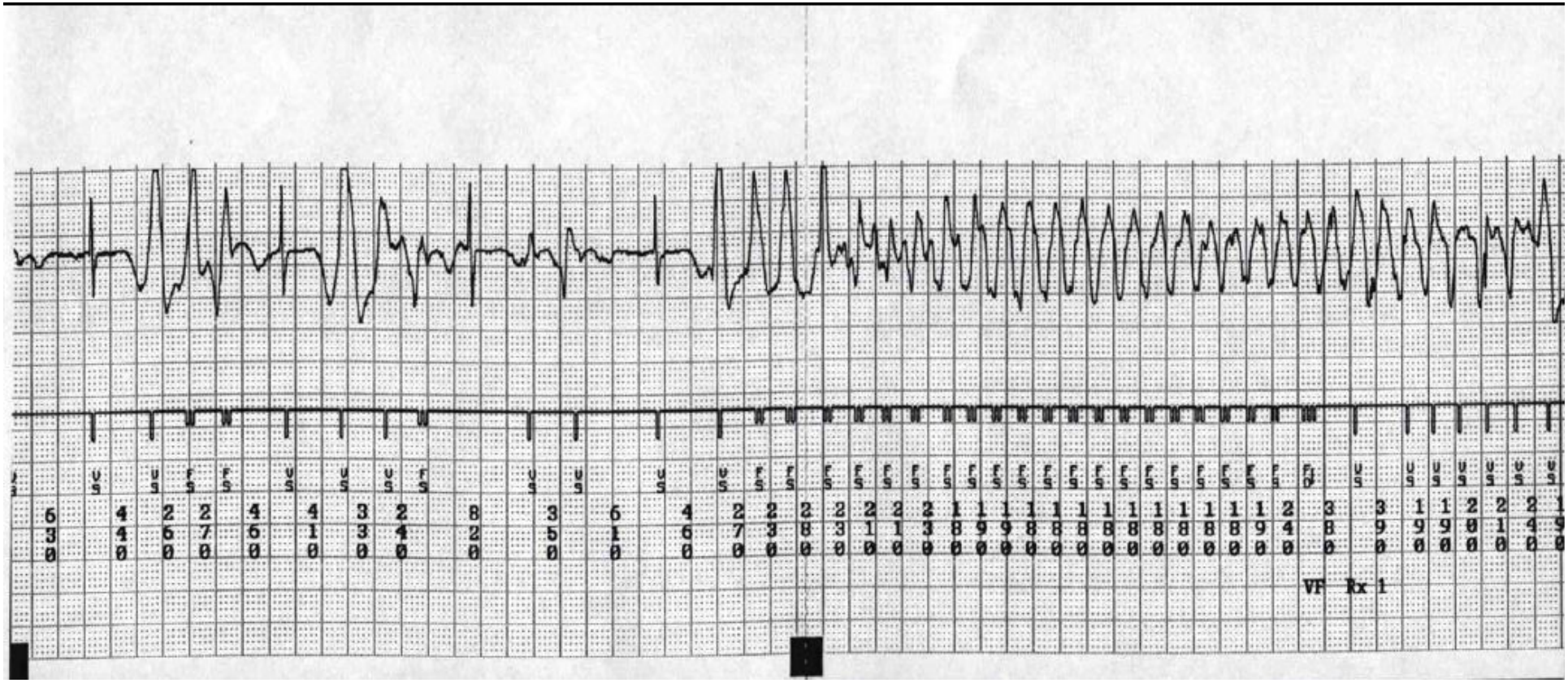
Committed Shock Therapy



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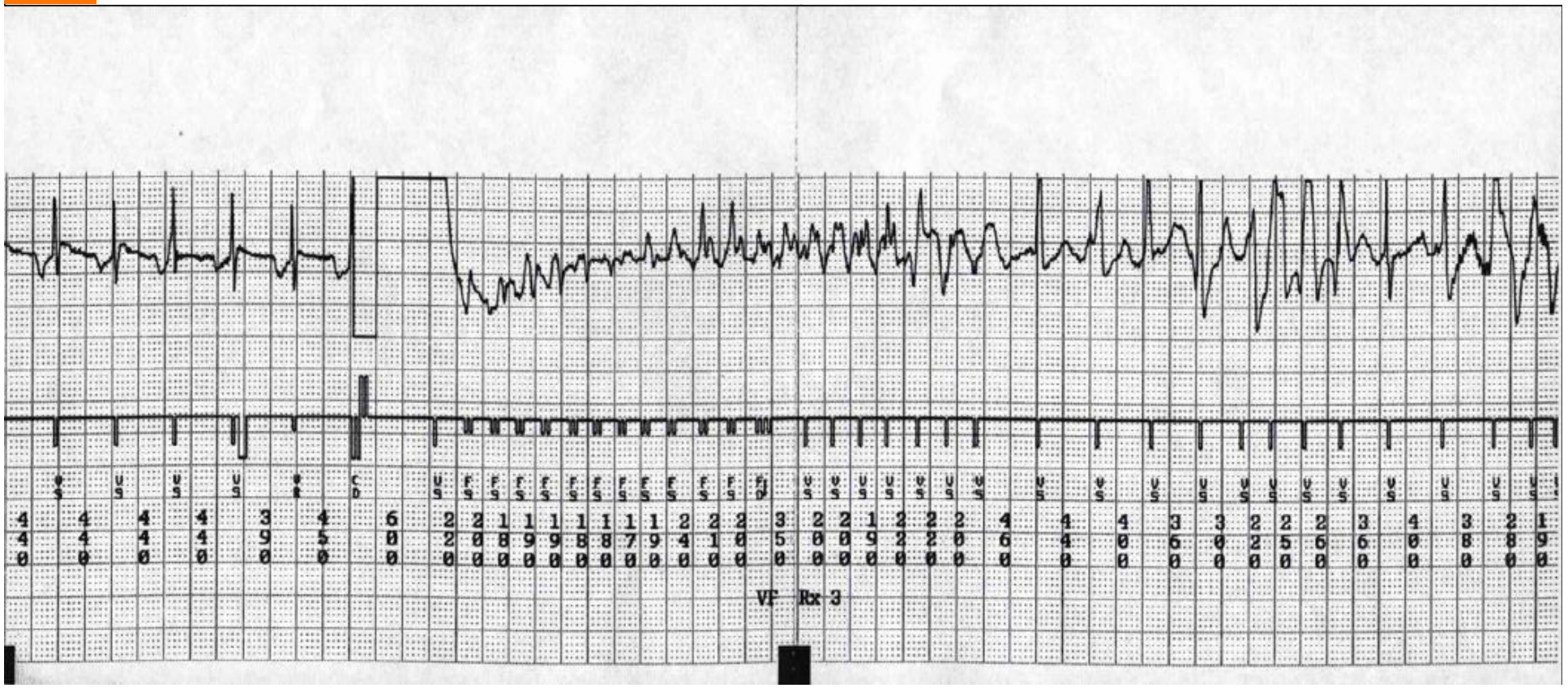
Committed Shock Therapy



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Sometimes it is blindingly obvious...

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Prevention

Surgical options

- Cephalic Vs medial subclavian

Appropriate programming

- fundamentals, ATP, SVT discrimination, rates, RV pacing reduction, tracking rates……

Medical (drug) therapy

- is it appropriate, did someone alter it?

Crystal balls

- Early detection, Home Monitoring

"I'll have an ounce of prevention."

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